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**The Official Journal of the Rocks and Minerals Association**

# *Chips from the Quarry*

## WE TRY AN EXPERIMENT

From time to time we have given specimens away, especially to young people, with the thought in mind of interesting them in collecting mineral specimens. Unfortunately, our hopes have not always been crowned with success. In most cases the apparent enthusiasm for mineral collecting in youngsters soon died out, with the specimens thrown away.

However, last summer we tried an experiment. It so happened that three young girls, ages 9, 11, and 13, were spending the summer with their aunt in Peekskill, who was our next door neighbor. The girls would come over, quite regularly, to examine our mineral collection and they seemed so intensely interested that we offered to take them on a field trip so that they could collect a few specimens for themselves. The girls became highly excited and talked enthusiastically over the coming excursion.

Within a few days the trip was made We visited an arsenic mine near Carmel, N. Y., where the girls had the unique experience of collecting "garlic rocks" (arsenopyrite). The famous Tilly Foster iron mine near Brewster, N. Y., and the Theall & McCollum iron mines, a few miles south of Brewster, were also visited and many specimens secured. The specimens collected by the girls were all good because we made them throw away those of poor quality.

On arriving home we instructed the girls to wash all their specimens (to remove dirt) and after they were dried to bring them over to our house and we would label them.

That evening, after all the specimens were labelled and each girl had her "collection" before her, we watched them carefully to see how they were reacting. They seemed immensely pleased with their specimens and commented on the thrills they would have when the collections were taken to their school and shown to the teachers and classmates. It was easy to see, however, that the girls were somewhat puzzled by their specimens. There was nothing about the pieces of "rock" they had to arouse pride of ownership or aesthetic delight. The names were difficult to pronounce, harder to remember. It was the girls' first adventure in the kingdom of minerals and they did not know whether the specimens they had gathered were princes or paupers.

Then it was that we made our experiment. We wrote on each label the actual price each specimen was worth. When the girls saw that some of the specimens were worth 25c, 30c and even 50c, then they were truly excited. Here was something they could understand and their specimens were no longer looked upon as mineral curiosities but things of potential value. It would have warmed the heart of a collector to have seen with what care and attention each specimen was wrapped up and how the girls raved over them.

The next day the girls left for their home in Pennsylvania. We were to keep in touch with them to learn how they were progressing with their mineral collecting. Unfortunately, a short time later, their aunt moved away unexpectedly, while we were absent on a trip, and we have not yet learned of her new address. But someday we will meet her again and we are very sure she will tell us that the girls still have their collections, are taking faithful care of them, and are seeking further mineralogical knowledge from such books as are available.

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# THE LUMINESCENCE OF CALCITE

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Morristown, New Jersey

During the past few years a great deal of interest has arisen in the fluorescence of minerals, among which even the common ones like calcite have received their share of attention. This mineral, which often shows some form of luminescence, is unusual in the diversity of colors emitted and in the presence, or absence, of the different forms from specimen to specimen. For instance, the well known Franklin calcite has a strong red fluorescence under the iron spark, but very little phosphorescence, whereas that from Brewster County, Texas, has both a spectacular blue fluorescence and phosphorescence. Thus we have the same mineral from different localities emitting light at opposite ends of the spectrum, not to mention still other specimens which give various colors in between, such as green, yellow and orange, some of them being fluorescent only, others both fluorescent and phosphorescent. There is also a wide variation in behavior depending on the source of ultra violet light used. Some specimens respond to the relatively weak, long wave radiation of the Argon bulb, some only to the intense short wave radiation of the iron spark, and still others luminesce in different colors under each one. Results with the cold-quartz lamp are apt to fall somewhere between.

All this raises the question of why minerals fluoresce and what makes all specimens of one mineral, such as autunite, behave alike, while others like calcite, vary so widely. It would also be interesting to know just how wide this variation is in any one mineral; whether there are seldom two specimens alike, or whether there are really only a few kinds of fluorescence and phosphorescence mixed in different proportions, so to speak. One way of finding out something about this is to test a large number of luminescent calcites under as many different conditions as possible, the most easily varied one being the source of ultra violet used. Thus each specimen could be tested under the Argon bulb and the iron spark, both of which produce some visible light which interferes with the observation of fluorescence so that a filter would be helpful. A convenient arrangement is the R. & M. lamp which can be used without a filter, resembling the iron spark somewhat, or with one (such as the Corning No. 986 dark red purple) in which case some of the very short wave ultra violet is cut off by the filter, but the net radiation obtained is much stronger and of shorter average wave length than that given by the Argon bulb. Another means of eliminating the effect of visible light is to confine the observations to phosphorescence, which of course, tells only half the story.

Another, and often very fruitful variation, can be introduced by testing the fluorescence and phosphorescence after heating the specimen to redness in a spoon over a gas flame for a few minutes. This may destroy the luminescence, leave it unchanged, or even intensify it.

Still further information might be obtained by testing the specimen for thermoluminescence (the property of emitting colored light when heated in the

dark below the temperature of ordinary redness), and for triboluminescence (the emission of light caused by fracturing a solid substance). In most cases, however, neither of these phenomena seem to have any connection with fluorescence.

The results obtained by these different tests should, if enough specimens were used, fall into groups of similar behavior, and it was found that they did. This in itself, doesn't tell us much more than we knew before, but in some cases examination of these groups gives a little information about the cause of that particular kind of luminescence, indicates further tests to make, and, at least, reduces the number of types to be investigated.

A more scientific approach to the problem is being made by those who have the necessary equipment. Their methods include spectrographic examination of fluorescence and phosphorescence over a wide range of temperatures, the spectrum usually tending to become sharper at the temperature of liquid air. In some cases it has been found that phosphorescence can be "frozen in." That is, if a suitable mineral is immersed in liquid air and exposed to ultra violet light, only fluorescence is produced, while the phosphorescence can be made to appear at any later time by simply allowing the specimen to warm up. The effects of cathode-ray bombardment are also being studied by various workers, and considerable work is being done on synthetic minerals to which small amounts of impurities are added in order to find out what connection they have with luminescence.

Using the simpler methods described above, the writer found that the luminescence of a number of calcites could be divided into more or less well defined groups which serve as a convenient basis for discussing the results.

## GROUP I — RED FLUORESCENCE UNDER THE IRON SPARK

The type example of red fluorescence under the iron spark is found in calcite from Franklin, N. J., many specimens of which show it strongly, though some from the locality fluoresce only faintly, or not at all. These, and many from other places, whether fluorescent or not, have a very brief red phosphorescence lasting about one-sixth of a second Many of them show a considerable red fluorescence under the R. & M. lamp equipped with a Corning No. 986 dark red purple filter, even though they may not respond to the iron spark. Among the latter are calcites from the Palisade Diabase at Weehawken, N. J., several from the pegmatites of North Carolina and Newry, Maine, one from the Levant mine, Cornwall, and a number from the vicinity of Franklin, N. J. None of these, however, are as bright as those which also fluoresce under the iron spark. Evidently this R. & M. lamp fluorescence is just a weaker variety of the red obtained with the iron spark, appearing in many specimens only when all visible light is filtered out. The brief red phosphorescence also seems to be directly connected in strength with this fluorescence. An Argon bulb is too weak to have any effect on the specimens in this class.

Brown (I) who worked with a set-up similar to the R. &. M. lamp and filter, found that red fluorescence in calcite is directly dependent on the manganese content, increasing rapidly in brilliance to a maximum at about 3.5% of this element, and then declining more slowly to zero at about 17.0%. In other words, the manganese impurity functions in some way to activate this type of fluorescence, the effect varying, as might be expected, with the concentration. Pure calcite is not fluorescent, while calcite with a little manganese is strongly so, until the manganese content becomes high enough that the mineral approaches the composition of rhodochrosite, which again is not fluorescent.

The brief red phosphorescence obtained with the iron spark apparently depends on the manganese content in just the same way, but is quite independent of any other luminescence which may be present. Thus it shows up strongly in calcite from Brewster County, Texas, but quickly gives way to a powerful and persistant blue phosphorescence.

The mineral has such a strong blue fluorescence that any red present is completely masked, even under the R. & M. lamp and filter. It would be interesting to examine the fluorescence with a spectroscope to see if any red is present, as one would expect it to be.

Although manganese is thought to cause red fluorescence and phosphorescence in calcite, it can also produce green in the mineral willemite, as well as a green thermoluminescence in non-fluorescent fluorite. Evidently both the host mineral and the means of excitation influence the color emitted; so that this cannot be used alone to determine the activating impurity. However, the spectrum in either case is probably a part of the normal one for manganese vapor.

It should be noted that, next to iron and magnesium, manganese is one of the commonest impurities in calcite, although not so frequently present in the approximate range of 1 to 10% which produces visible red fluorescence. It is more often too low than too high. Most of the calcites having the proper concentration are distinctly crystalline, or cleavable massive, usually representing the first generation of deposition.

There is also some evidence that both magnesium and iron tend to inhibit this type of fluorescence, even if the manganese content is favorable, although, as far as as the writer knows, this has not been worked out quantitatively. At any rate the phenomenon is not shown by siderite or dolomite which, taken alone, doesn't prove anything one way or the other.

Careful tests on a series of calcites from Franklin and Weehawken, N. J., in which the fluorescence varied from pale pink to deep red, indicated that there is no simple connection between the strength of fluorescence and that of the yellowish thermoluminescence they all showed.

Triboluminescence was observed in only two specimens, a non-fluorescent one from Easton, Pa., and a strongly fluorescent one from Franklin, again showing a lack of connection between these properties and fluorescence.

Heating the specimens to bright redness for several minutes was without effect on the color or strength of either fluorescence or phosphorescence.

GROUP II — GREENISH FLUORESCENCE UNDER THE ARGON BULB—DESTROYED BY HEAT.

Most of the calcites in this group are granular and all appear to have been formed under near-surface conditions. They are listed below:

1. Cincinnati, Ohio* — yellowish-grey gravel bed crust.
2. Sage Creek, Pennington, Co., South Dakota—thin grey coating on limestone.
3. Ogdensburg, N. J.—fine granular brownish mass.
4. Echelles Grotto, Savoie, France—yellowish-white flat stalagmite.
5. Norée Grotto near Poitiers, France —yellow-brown flat stalagmite.
6. Cave of Glandieux, Isére, France—white spongy mass.
7. Terlingua, Texas — deep amber coarse radiated crystals.

Under the Argon bulb these specimens have a greenish or yellowish-green fluorescence of variable intensity, No. 1 being most strongly green, and No. 3 weaker, but more yellowish. The phosphorescence is pale yellowish or bluish-green, fading quickly into white and is most brilliant in specimen 3. It may be mentioned at this point that the phosphorescence of many minerals appears white if weak or almost faded out, due to the fact that the color perception mechanism of the eye ceases to function when the light becomes too dim, and then only differences in intensity can be detected.

No fluorescence was obtained with the iron spark (due probably to the strong visible light furnished by this source), while the phosphorescence was stronger than that under the Argon bulb, and the variation in color more pronounced, be-

* This specimen was obtained from Mr. H. Wuestner of Cincinnati, who described the mineral in *"Rocks and Minerals"* for April, 1936.

ing green in Nos. 1 and 5, bluish-green in No. 6, greenish-blue in No. 4, yellowish-green in No. 3, and greenish-yellow in No. 7. The R. & M. lamp with filter produced a much stronger but somewhat more yellow fluorescence and phosphorescence than did the Argon bulb, irrespective of the shade obtained with the latter.

Heating these specimens to redness for several minutes causes them to turn various shades of grey, and greatly decreases the strength of fluorescence and phosphorescence, when tested with the Argon bulb after cooling. In fact, no fluorescence at all could be detected after heating in any specimen except No. 7, although but No. 6 retained a very little of their original phosphorescence (about 5% by visual estimation). The heated specimens, like the originals, did not fluoresce under the iron spark, while their phosphorescence was reduced about 95% of that of the unheated material.

With the exception of No. 7 which had a strong greenish-yellow thermoluminescence, all lacked this property almost completely, which is somewhat remarkable, considering that only these few specimens out of about 100 from different localities failed to show a yellow or orange-yellow thermoluminescence.

The similarity of Argon bulb fluorescence in these specimens to that shown by petroleum, amber, varnish resins, and certain bituminous materials together with its destruction by heat, with greying (or slight charring) of the specimen, strongly suggests that this type of fluorescence is due to included organic matter of a bituminous nature. This idea was tested by dissolving samples of specimens 1, 3, 4, and 5 in hydrochloric acid, diluting slightly and extracting the solution three times with reagent grade benzene which had been further purified by redistilling it over sodium. The extractions were made in a glass-stoppered glass cylinder, and the extracts were siphoned off into a small flask in which they were evaporated to dryness. (A composite of the group was used instead of individual samples of each specimen because the supply was limited). Evaporation of the combined extracts gave a few droplets of a dark yellowish brown oil. A blank which was run on an equal volume of the benzene was found to be practically zero, only a very faint trace of a white crystalline material being obtained. This was only about 1/50th of the amount of oil from the calcite, proving that at least one of the specimens in the composite contains an oily organic impurity. The latter fluoresced dull yellowish green under the Argon bulb when tested through the wall of the flask, as did the very small blank from the benzene, but neithor one phosphoresced. This would seem to indicate that the oily impurity in these calcites may be responsible for fluorescence, but not phosphorescence, which is in agreement with the fact that phosphorescence is a property of crystalline solids and is not found in liquids or amorphous materials. However, it seems reasonable to assume that the crystal structure of calcite could influence an impurity, even if liquid, in such a way that it would become uniformly distributed throughout the crystal lattice and could thus act as if crystalline itself by phosphorescing. It is of interest that extracting a small, finely ground sample of these calcites several times with boiling benzene did not materially reduce the phosphorescence of the powder (although visible fluorescence was destroyed by grinding). This tends to indicate that whatever impurity is responsible for phosphorescence is extremely finely divided in these calcites. Furthermore, a portion of the oil which had been melted with a non-fluorescent wax and allowed to solidify, fluoresced more brightly than the oil alone, showing that distributing the oil in a base material can change its luminescence.

Stated another way, in fluorescence, particles in the substance are raised to a so-called higher energy level by the impact of the ultra violet light and fall back at once with the emission of visible light (somewhat like pebbles splashing into a pool). In phosphorescence, on the other hand, the surrounding crystal lattice catches and holds the excited particles for a little while, thus delaying

their return to the orginal state, and prolonging the emission of light after the ultra violet is shut off. It might be possible for particles knocked out of the above oily impurity to be delayed in their return to the original state by the influence of the surrounding calcite crystal structure so that phosphorescence might occur in the mixture, though lacking in the oil alone. It is to be noted that heating practically destroyed the phosphorescence of these specimens as well as their fluorescence, indicating a common source for both. The possibility suggests itself that heating does not really destroy the phosphorescence, but only obscures it by charring the oily impurity. However, it was noted that the specimen from Terlingua, Texas, which had the strongest residual phosphorescence after heating (but very much weaker than the original) also showed the most pronounced blackening.

On the basis of the foregoing, it seems likely that both the fluorescence and phosphorescence of the specimens in this group are due to the presence of an oily organic (probably hydrocrabon) impurity which is in itself fluorescent, but only phosphoreses when dispersed in the calcite, chars when the mineral is heated, and probably prevents thermoluminescence to some extent in so doing. The indefinite composition of such an oil probably accounts for the slight differences in the fluorescence and phosphorescence colors noted in these calcites.

It is interesting that considerable amounts of aluminum, iron, and kaolin which were also found in the above composite sample apparently do not interfere with the luminescence.

A number of other minerals fluoresce and phosphoresce in colors similar enough to those of the above calcites to suggest that their luminescence is also due to an oily or bituminous impurity. Among these are several selenite crystals from clay beds in different localities, fluorite from Clay Center, Ohio, (which also blackens when heated, loses its fluorescence ,and is not thermoluminescent, unlike the vast majority of fluorites), barite in clay ironstone from Georgia, witherite from Hexham, England, and strontianite from Hamm in Westphalia, Germany.

### GROUP III — HEATING PRODUCES A YELLOW ARGON BULB FLUORESCENCE, BUT TENDS TO DESTROY PHOSPHORESCENCE.

This group is somewhat similar to the preceding one, but is distinguished by the fact that heating produces a yellower and often stronger fluorescence than that of the original specimen, instead of destroying its luminescence. The following specimens were found to behave in this manner:—

1. Haverstraw, N. Y. — 2nd generation, golden crystals.
2. Bernardsville, N. J. — small yellowish rhombs.
3. North Plainfield, N. J.—2nd generation, large colorless crystals.
4. Vivonne (Vienne), France — layers of light brown travertine.
5. Norée Grotto (Vienne), France— yellowish spongy mass.

The Argon bulb fluorescence of the first three is a dirty yellowish-green which appears to be concentrated just inside the edges of the crystal, while that of the other two is pale bluish-green throughout. The phosphorescence, while too faint to describe accurately, seemed slightly bluish-white in specimens 2 and 4, and faintly greenish-white in the others. All darken slightly when heated to redness in a spoon for a few minutes, but only the first three exhibit the usual orange-yellow thermoluminescence of calcite. The fluorescence induced by heating was much yellower and considerably stronger than that of the orgininal mineral in the first three specimens and so much weaker, although yellower, in the two from France that it was at first overlooked. The phosphorescence under an Argon bulb was much weakened in all five specimens, possibly most in the last two, and gave only the sensation of white.

When tested with an iron spark, the behavior of the first three specimens under the Argon bulb was reversed in that

they had a stronger phosphorescence after heating than before. Specimens 4 and 5, on the other hand, were more nearly like those of group II as the strong bluish-green iron spark phosphorescence of the original material was greatly decreased by heating. Fluorescence under the iron spark was practically lacking, both before and after heating, being probably obscured by the strong visible light (except in the Bernardsville specimen which gave a pale green). Heat treatment also induced a moderately persistent reddish phosphorescence in the calcite from North Plainfield when tested with the iron spark. This color, which was not seen in any other specimen, was more orange-red, and of far longer duration than the typical manganese phosphorescence of group I, although the latter seemed to be present in the unheated mineral.

The R. & M. lamp with filter produced a strong greenish-yellow fluorescence in all these specimens.

The strong yellowish Argon bulb fluorescence induced in the first two by heating is apparently only slightly excited to phosphorescence by the weak long wave radiation of this light source, but phosphorescence under the short wave U. V. from an iron spark is stronger than in the original. This may be due to the fact that the charred matter present in the mineral after heating screens out the weak radiation from an Argon bulb, thus preventing phosphorescence (the strong Argon bulb fluorescence may be largely on the surface of the calcite), whereas the relatively strong radiation from an iron spark is able to get through to the inside of the crystal and cause the whole thing to phosphoresce brilliantly. However, no difference in phosphorescence strength was observed in different sized fragments, even the very smallest behaving just like the large ones; from which it would seem that a separate and distinct type of phosphorescence, excited by short wave ultra violet, is produced in the first two specimens by heating. This is certainly the case with the orange-red phosphorescence induced by heating the North Plainfield calcite. The matter is further complicated by the presence in the original specimens of an impurity, the luminescence of which is destroyed by heat, like that of group II, and which is probably also a hydrocarbon oil. This is born out by the fact that heating the last two specimens produces a net decrease in intensity both under the iron spark and the Argon bulb, although a new yellow fluorescence is also induced which is similar in color to that of the first three, where the proportions of the two kinds of impurity are reversed. In other words, there is relatively little of the heat-unstable factor in the first three and more of the impurity responsible for the new yellow fluorescence; so that the net result of heating is to increase the fluorescence intensity in these specimens. That an impurity of some kind or other is responsible for the observed intensification of luminescence is suggested by the zoned fluorescence of the first three specimens, and its organic nature, by the darkening of all five when heated. In the case of the American calcites relatively little oily matter is present as shown by its failure to inhibit thermoluminescence, whereas, by this standard, there must be more in the two non-thermoluminescent ones from France. This is in agreement with the net reduction in fluorescence intensity of these two specimens by heating.

Little of a definite nature can be said at this time about the source of the yellowish fluorescence produced by heating, although several possibilities suggest themselves. One is that heating has destroyed or vaporized something that prevented still another impurity from causing fluorescence. For instance, an organic impurity might be charred and destroyed by heating, or driven off, as would be the case with included water. The former seems unlikely because none of the specimens in group II, many of which blacken to a greater extent than the ones in this group, and which contain an oily organic impurity, show the phenomenon. Likewise, driving off included water might permit some other impurity to produce fluorescence, or, at least, would tend to leave tiny cracks and spaces

in the calcite and to distort the crystal lattice, which alone is said (2) to be enough to produce fluorescence in a large number of substances. That loss of included water isn't connected with yellow fluorescence after heating these specimens was shown by heating equal-sized samples of calcites Nos. 1 and 4, as well as a composite sample of group II, and one specimen from group IV in closed glass tubes, the water being driven off and condensing on the wall of the tube. None of the specimens tested gave more than a very faint trace of water, and the amount was the same for the Haverstraw specimen (with a good yellowish fluorescence after heating) as for the composite of group II which has none at all. Slightly more water was found in No. 4 (which has only a faint fluorescence after heating) than in No. 1, and least of all in the specimen from group IV (A, No. 1) which had by far the strongest yellowish fluorescence after heating.

Another possibility is that heating breaks down the calcite itself to some extent by driving off carbon dioxide, thus leaving microscopic spaces in the crystal. This was found by Ewles (3) to produce phosphorescence in calcite if heating were carried far enough to form a mixture of calcium carbonate (calcite) and calcium oxide (quicklime), but not if only the pure oxide (or carbonate) was present alone. To test this a white translucent crystal of calcite from Paterson, N. J., having an excessively faint phosphorescence, was heated to redness for several minutes, just as were the above specimens, but not the slightest change in either phosphorescence or fluorescence under the iron spark or Argon bulb was produced. Thus it seems clear that partial decomposition of the calcite by heat is not the cause of the intensification and color change in fluorescence observed under the conditions of the above experiments.

Again, heating might partially break down some inorganic compound present as an impurity in the calcite in such a way as to cause the residue to activate luminescence. Thus certain metallic oxides (for example, pyrolusite) readily lose part of their oxygen when heated, and many bicarbonates lose carbon dioxide and water with the formation of carbonates, somewhat similar chemically to calcite. If such a compound were present as an impurity, and were broken down by heat to a substance which could diffuse in an orderly manner through the calcite crystal, or replace part of it, we might expect fluorescence to be produced. On the other hand, it might only be necessary for an inorganic impurity (or a heat stable organic one) to diffuse throughout the crystal under the influence of heat, without any decomposition at all, for it to give the same result. While the latter suppositions are purely guesswork, they seem to be in accord with the evidence that some impurity which does not cause fluorescence except after heating is present in the specimens of this group.

As still another theory, it was found by Chomse and Lutzenberger (4) that a luminescent calcite could be made in the laboratory by precipitating a solution of calcium nitrate with ammonium carbonate, to which had been added very small amounts of various organic chemicals containing nitrogen (such as uric acid, and the acids resulting from the decomposition of proteins). The resulting precipitate of impure calcium carbonate was heated to about 400 degrees centigrade for a short time, after which they found it to have a yellowish fluorescence, and a green or bluish-green phosphorescence. It seems possible that their synthetic calcite is similar to the natural specimens of this group in that the latter were all formed under near-surface conditions and could easily contain inclusions derived from decaying protein matter. In addition, heating produced a yellowish fluorescence in both these specimens and the synthetic material (although the same cannot be said of the phosphorescence color), and the temperature used in these experiments was about the same as that employed by the above workers. This was shown by the fact that fragments of aragonite could not be made to change over to

calcite when heated in the spoon used for heating the calcites unless it was covered. Since the change takes place at 470 degrees centrigrade, the temperature reached by pieces of the specimen in an uncovered spoon must have been somewhat below this figure, or around 400 degrees centigrade. Thus it might be assumed that there are two distinct types of organic impurities which cause fluorescence in these calcites; bituminous (heat-unstable) as in group II, and a mixture of bituminous and protein-like as in this group. Although this is also guess-work, it seems to the author that it offers the most plausible explanation of the observed facts. However, any other theory that the reader cares to make up for himself and which he can support with a little evidence is probably just as good.

GROUP IV HEATING INTENSIFIES PHOSPHORESCENCE UNDER THE ARGON BULB, AS WELL AS FLUORESCENCE, IF PRESENT.

The specimens in the first subdivision of this group are characterized by the fact that heating them to redness for a few minutes in a spoon intensifies both fluorescence and phosphorescence under the Argon bulb. The phosphorescence of unheated calcites in both subdivisions tends to be white rather than greenish, while that of the second is intensified by heating, although no change is produced in fluorescence which is practically absent in the original specimens. The following calcites were found to fall in one subdivision or the other, but the distinction is often not very clear-cut.

SUBDIVISION A.

1. Viviers (Ardéche), France—white cleavages.
2. Prospect Park Quarry—Paterson, N. J.—colorless, built-up crystal, and yellowish rhombs.
3. Aïn-smara, Algeria—coarse grained, slightly columnar marble.
4. Iteuil (Vienne), France — brownish, partly crystallized mass.
5. Chisos Mts., Brewster County, Texas—greenish or reddish cleavages.

SUBDIVISION B.

6. Near Couz Falls (Savoie), France —very fine grained, white limestone.
7. Near Echelles Grotto (Savoie), France—fine grained greyish white crystalline limestone.
8. Echelles Grotto (Savoie), France —very fine-grained white limestone pebbles.
9. South Dakota—white cleavage fragment with "growth rings."

The Argon bulb fluorescence of the first 4 specimens is exceedingly faint greenish, and the phosphorescence, which is by far the strongest in No. 1, very faint white, with just a trace of green in Nos. 1, 3 and 4, and blue in Nos. 2 and 5. The last 4 specimens are almost non-fluorescent and only very dimly phosphorescent, with the exception of No. 9 which gave a moderate white phosphorescence and yellowish-green fluorescence.

The results after heating were in most cases far from spectacular, it being possible to detect the intensification in luminescence only by placing a heated fragment directly upon the unheated specimen from which it came, and testing the two together under the Argon bulb. Exceptions were No. 1, which, after heating, had a strong greenish-yellow fluorescence distributed in specks throughout the specimen, and a much intensified, slightly yellow phosphorescence of longer duration than the original. Specimen No. 9 was similar, but slightly greener and weaker, while No. 2 was still weaker though stronger than the original. No. 5 had a powder-blue fluorescence and green phosphorescence about 10 times as strong as that of the original. The fluorescence of No. 9 was also changed to a very dim greenish-yellow. The new greenish-yellow fluorescence of Nos. 1 and 2 was not diminished by placing a piece of window glass between the specimen and the Argon bulb, showing that it is excited by very long-wave ultra violet.

The iron spark gave more clear-cut results, indicating that all 9 of these specimens are similar enough to be

placed in a group, with the possible exception of No. 1. The latter also bears some resemblance to the calcites of group III, but is discussed here because of the intensification of phosphorescence under the Argon bulb when heated. As might be expected, these specimens were not fluorescent under the iron spark with the exception of No. 5 which gave a strong blue. The phosphorescence of all unheated specimens except No. 1 which was faintly yellow, was either light or dark blue, being faintest in No. 2 and strongest and most persistent in the Texas calcite (No. 5). The luminescence of the latter is most spectacular, and is closely associated in strength with green or reddish spots in the mineral, being almost lacking in colorless portions. Heating produces a yellowish phosphorescence in all these specimens under the iron spark except No. 5 which remains blue. This is strongest for No. 1 in which it is also accompanied by a slight fluorescence, while in some it is so weak that the original blue phosphorescence gives the effect of a greenish or yellowish mixture, for instance, yellowish-green, next in strength to No. 1, in No. 2 (which, however, is not fluorescent under the iron spark).

With the Texas calcite, the blue phosphorescence, which shows the unusual behavior of getting deeper in color as it fades out, is so strong that it completely masks any new phosphorescence induced by heating. This can readily be seen, however, under the Argon bulb which excites the original blue very weakly, thus giving the new greenish phosphorescence a chance to show up. While this may be entirely different from that of the others in origin, it may simply be a mixture of an intensified blue with some factor produced by heat and similar to that of the others. Apparently the strength of blue fluorescence is increased enough by heating that it can be seen under an Argon bulb. This specimen also showed a very brief red phosphorescence under the iron spark like that of group I. This is no doubt due to manganese and was not changed by heating.

A similar brief red phosphorescence, not present to any extent in the original specimen, was made visible in No. 4 by heating, indicating that some impurity which suppressed it had been destroyed by this treatment, or that the manganese, to which it is probably due, had been changed to an active form.

The R. &. M. lamp with a filter produces only a faint fluorescence and phosphorescence in all of these specimens except No. 5, and nothing very unusual after heating.

Thermoluminescence is the usual orange-yellow of varying strength, except in specimens 1, 3, and 9, where it is faint bluish white. The orange yellow thermoluminescence of the calcite from Prospect Park (No. 2) is much stronger and comes up more quickly in the outer portions of the crystal, which have the appearance of being built on to it, and which alone show the above mentioned increase in fluorescence and phosphorescence under the Argon bulb after heating. This might lead to the conclusion that the same impurity is responsible for both thermoluminescence and the new fluorescence. One would further expect this impurity to be inorganic, as an organic substance would probably be too easily destroyed by heat to be connected with thermoluminescence. However, these ideas are disproved by the fact that specimen No. 1, which, under the Argon bulb behaves somewhat like the outer portion of No. 2 when heated (except that No. 1's new luminescence is about 10 times stronger) only has a pale bluish-white thermoluminescence. This indicates that the strong yellow thermoluminescence in the outer portion of No. 2 is just a coincidence and has no connection with the stronger fluorescence after heating. It also serves to illustrate the advantage of testing several specimens, as the behavior of No. 1 prevented jumping to an erroneous conclusion about No. 2. The iron spark phosphorescence of No. 2 after heating differs slightly from that of No. 1, being more greenish, probably because of the additional presence of a blue phosphorescence in No. 2 before

heating. This further serves to illustrate the complexity of the problem, though a comparison on the basis of the Argon bulb behavior is apparently valid.

It is interesting, though probably not significant, that the label on No. 1 stated that it contains strontium, which is not an element that one would expect to activate luminescence in calcite. Specimen No. 2 which behaves similarly was found to contain about 0.005% strontium when tested on the spectrograph. Thus, there is a possibility, though by no means definite, that strontium is connected in some way with the luminescence of these two specimens.

The significant feature of this group is that the specimens comprising it nearly all have a bluish phosphorescence under the iron spark, on which a yellow is superimposed by heating. In this last respect they are somewhat similar to the first two specimens in group III and the same general remarks as to the mechanism involved can be applied with equal lack of conclusive evidence. It should be noted, however, that the phosphorescence of these specimens after heating differs from that of the Haverstraw calcite (group III, No. 1) in that it is stronger than the original under both the Argon bulb and the iron spark. In the Haverstraw specimen phosphorescence was much weaker than the original under the Argon bulb, but stronger under the iron spark. The author inclines to the theory that the production by heat of yellowish phosphorescence under the iron spark and, in some cases, yellowish-green fluorescence under the Argon bulb is connected in some way with protein-like inclusions or their decomposition products. However, the lack of charring in specimens 2, and 9 tends to indicate the absence of organic matter, or, at least that the kind present is not readily blackened by heat. This seems to leave an inorganic, probably heavy metal, impurity as the other alternative, and since nothing is definitely known about the kind of impurities actually present in these calcites, the matter must be left undecided at this time.

GROUP V—MISCELLANEOUS.

So far only one calcite has been observed that did not have any resemblance to at least one of the preceding groups, namely, a clear cleavage piece from Imperial County, California. This had greyish clay-like inclusions at one end, showed a faint orange fluorescence under the Argon bulb and R. & M. lamp with filter, but did not phosphoresce. It did not respond at all to the iron spark, and the observed fluorescence seemed to be associated with the inclusions. Heating was without effect on either property, and the specimen had the usual orange-yellow thermoluminescence.

SUMMARY

In conclusion it may be well to list what appear to be the various kinds of luminescence found in the above calcites.

1. Reddish fluorescence excited by strong short wave ultra violet from the iron spark or R. & M. lamp, and accompanied by a very brief red phosphorescence. This type is exemplified by group I and is undoubtedly due to manganese.
2. Greenish fluorescence and greenish phosphorescence fading to white. This is best excited by long wave ultra violet as from an Argon bulb, and is easily destroyed by heating the specimen. The calcites in group II are examples of this type, which is apparently due to oily hydrocarbon inclusions.
3. Greenish - yellow fluorescence, produced or intensified by heat treatment, most strongly in the calcite from Viviers (Ardéche) (group IVA, No. 1), and also noted in the specimens of group III. This is excited by very long wave ultra violet. The Argon bulb phosphorescence connected with this fluorescence is stronger after heating than in the original with the specimens of group IV, and weaker than in the original with group III due to to the presence of heat unstable, and other luminescent factors. Phosphorescence under the iron spark after heating is generally yel-

lowish and stronger than that of the original specimen. This type is probably traceable to inclusions of protein decomposition products, or other nitrogen-containing organic matter which is changed by heating in such a way as to cause luminescence.

4. Strong yellowish phosphorescence observed after heating the specimen from Haverstaw, N. Y., and to a less extent the one from Bernardsville, N. J. This was excited by the iron spark, but not the Argon bulb, and probably represents a distinct type of luminescence, though it may be simply a case of the above type (No. 3) complicated by the presence of other factors.
5. Bluish phosporescence strongly excited by the iron spark and only faintly, or not at all, by the Argon bulb. This type is apparently not changed by heating, and is accompanied by blue fluorescence only when a large amount of the impurity causing it is present, (as in the Texas calcite). There is a possibility that it is due to the presence of rare earth elements, but this would be very difficult to determine.
6. Reddish phosphorescence of relatively long duration which is produced by heating, and is only excited by the iron spark. This was observed in a single specimen from North Plainfield, N. J., and nothing whatever is known as to the cause of it.
7. Orange fluorescence without phosphorescence seen in one specimen from Imperial County, California. This was excited by the Argon bulb, or R. & M. lamp with filter, but not the iron spark. Nothing can be said about the cause of it, except that it seems to be associated with clay-like inclusions.

Although there may be other types of fluorescence and phosphorescence than these in calcite, none was observed using the crude methods and limited number of specimens discussed here, with the possible exception that the heat-unstable fluorescence of group II may have a more complex origin than has been considered. However, it would seem that, in general, the luminescence of all specimens studied can be boiled down to one of the above rather broad types, or to a mixture of them.

## ACKNOWLEDGEMENTS

The author is indebted to Mr. Maurice Déribéré of Courbevoie (Seine), France, for first calling his attention to the change produced in the luminescence of certain calcites by heating, and for very kindly supplying all of the above specimens from French localities. He is also indebted to Mr. O. Ivan Lee, a member of the Rocks and Minerals Association, for the loan of an iron spark, and to Mr. Harry Charles Grahl, also a member of the Association, for the R. &. M. lamp and filter employed. In addition Mr. Lee made the spectrographic test for strontium in the Prospect Park Calcite at the laboratories of Lucius Pitkin, Inc., New York City.

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# LINCOLN CAVERNS OF PENNSYLVANIA

One of the most interesting caverns in Pennsylvania, which this month is celebrating the 10th anniversary of its discovery, is the Lincoln Caverns near Huntingdon. Ever since they were opened up to the public, the caverns have been attracting more and more visitors every year due to their very interesting formations, and should be of special interest to all members of the Rocks and Minerals Association because Mr. M. C. Dunlavy, President of Lincoln Caverns, Inc., is one of our members.

## HISTORY

Lincoln Caverns, formerly known as the Wm. Penn Caverns, were discovered in May, 1930, when the new location of the Wm. Penn Highway, was being graded. Holes drilled in a limestone spur dropped 20 feet or more, thus indicating that a large cave was underground. The necessary blasting and excavation exposed the cave whose existence had never been suspected.

The cave was on the farm of Harry B. Stewart, who, after exploring it thoroughly, as far as it was possible, and realizing its commercial prospects, had the entrance barricaded, while he, with his sons and a brother, worked many months in cleaning out those rooms and passages which were blocked with clay and sand; installing electric lights, and enlarging some of the passageways. A surveyor was later employed to make a map of the caverns. On June 25, 1931, when the caverns were opened to the public, about 500 feet of underground passages were ready for visitors.

They were first called the Hi-wa-may Caverns, a name derived from their position besides a highway and the month in which discovered. In February, 1932, the name was changed to Wm. Penn Caverns because of their location on Wm. Penn Highway.

The above history is taken from *Pennsylvania Caves,* by R. W. Stone, Harrisburg, Penn., 1932, pp. 87-88.

In May, 1937, the caverns were purchased by Myron C. Dunlavy, Hamburg, N. Y., Edward B. Archbald, Waterport, N. Y., and Chester O. Gale, Buffalo, N. Y., who changed the name and operated them as Lincoln Caverns, Inc.

## LOCATION

The Lincoln Caverns are located on the west side of Warrior Ridge, about 3 miles west of Huntingdon, Huntingdon County, approximately in the south-center of the state and on U. S. Route 22, the main highway between New York City and Pittsburgh.

## LAYOUT

The Lincoln Caverns property consists of 40 acres with frontage on both sides of U. S. Route 22, with underground rights of 90 acres.

One enters the caverns at highway level and follows along a half-mile of dry, gently sloping gravel paths for 40 thrilling minutes of exploration. Miraculous grandeur and unrivaled beauty meet the eye along the many passageways and chambers that are adorned with countless stalactites, stalagmites, and glistening flowstone formations. Here one will find a veritable wonderland of fantastic forms to inspire the imagination of all visitors. One will see Pagoda Avenue,, the Bearded Palace, the Frozen Niagara, the Devil's Pit, the Path of the Nymphs, Wall Street Canyon, and many other vaulted chambers and passageways.

Even so the caverns are but partly explored as many passageways are completely choked up with clay. Recently a new room was cleaned out which proved to be the most beautiful found so far. It is about 27 x 16 feet in area with the ceiling reaching to a height of 50 feet in some places. Many very interesting geological formations were found in this room such as petrified worms, crystals, and dripstone formations of extraordinary beauty and a large stalagmite 7 feet high and 4 feet in diameter. It was also surprising, upon breaking through the cave clay, which had completely sealed up the entrance to this room, to find two bats and quite a few flies. Upon further investigation, other channels were discover-

*Cavern Entrance*
*40 feet from U. S. Route 22*
*Lincoln Caverns*



*Pagoda Avenue*
*Leading to the Mystery Room*
*Lincoln Caverns*



*Giant Stalactite*
*Above Subterranean Spring*
*Lincoln Caverns*

*Stone Cascade in Wonder Canyon Lincoln Caverns*

ed leading deeper into this mysterious and fascinating laboratory of nature which cannot be explored further until more excavation is done. This room has been named "The Mystery Room" as beyond its closed portals must be many magnificent subterranean wonders.

On top of the ridge directly above Lincoln Caverns is another opening which has been followed down about 20 feet into the upper channels of what seems to be a series of rooms at a high level. Attention was attracted to this spot by the fact that snow always melted in the winter on a huge pile of rocks covering it. As the temperature inside the caverns remains constant 52° F. throughout the year and investigation showed the snow was being melted by warm air rising from below, the rock pile was removed. Under it was found an entrance into a room beneath a capstone of solid limestone. Through a crack in the limestone wall can be seen what appears to be the roof of a large cave. A strong current of cool air escapes from this opening. Further explorations will be carried on in this section during the summer of 1940.

A curious thing about this opening is that a large piece of beautiful crystal rock was found about 15 feet deep in the topsoil clogging it. Crystals of this kind have not been found any place else around the caverns.

## GEOLOGY

Lincoln Caverns are in the Helderberg limestone which strikes E-W and dips 70° N.*

Along the crest of Warrior Ridge are many spots of geological interest. Several sandstone "rock cities" may be seen, isolated piles of rock 50 feet high with passageways from 1 to 10 feet wide between them. The best example of this type of formation, know as Pulpit Rocks, has been donated to Juniata College, at Huntingdon, to be permanently preserved as a natural curiosity. Nearby is a large bowl-shaped depression covering more than an acre of ground supposed to have been formed by the solution of the underlying lower Helderberg limestone, thus allowing the overlying Stormville shales to fall into a cavern. This depression drains many acres and it is believed the water from it, sinking through the limestone passages, collects underground and finds an exit by way of large caverns into a great fountain of water known as Blue Spring instead of making a surface stream. This spring is at the base of the ridge and has been famous since the days of the Indians for its large size, and very cool, clear water. Rock View, a great cliff rising almost perpendicularly to a height of nearly 400 feet, is in this vicinity. Also of interest are the small petrified shells, brachiopods, found on top of Warrior Ridge over Lincoln Caverns.

Very fine specimens of calcite, crystallized in stalactitic growths, have been found in the Mystery Room.

## CONCLUSION

Lincoln Caverns are 1200 feet above sea level (700 feet above Huntingdon).

* Stone, R. W., **Pennsylvania Caves**, Harrisburg, Penn., 1932, p. 90.

They, themselves, not only are an attraction to lure visitors from near and far but the scenery of the area is very beautiful. Spacious picnic grounds are available on the property, with a restaurant on the premises and fresh, cool water from a 215 foot well.

When the caverns reopen on May 15, 1940, it is planned to keep them opened permanently the year round—the temperature is constant underground (52° F.).

Experiments made during the summer of 1939 at several places in the caverns with ultraviolet lamps produced amazing results. So the electric lighting system is to be improved in 1940 by the permanent installation of these lamps where they were found to be most effective.

It is also planned to secure in 1940 a collection of rocks and minerals for exhibition in the reception room. A large massive fireplace in this room, constructed of cave rock and formations attracts so much attention that it is believed a mineral collection would be of even greater interest.

## MINERAL DAY AT THE WORLD'S FAIR

**(New York City)**

### Monday, June 17, 1940

**Specially set apart for you and all persons interested in mineralogy**

### PLAN TO BE THERE

The second meeting of the National Advisory Committee of the Mineral Day at the World's Fair was held on Wednesday, March 27th, in th offices of Mr. Joseph D'Agostino, Chairman, in the RCA Building, Radio City, New York City. The Committee discussed plans for the proposed program and the individuals who will be in charge.

The big event is creating considerable interest throughout the country judging from the large number of letters pouring into the offices of *Rocks and Minerals*. Collectors from everywhere are planning to attend and they are very enthusiastic about it, too. From all indications, the Mineral Day at the World's Fair will be the greatest mineralogical show ever staged on earth.

The Mineral Day at the World's Fair will be a non-commercial event intended only for the purpose of stimulating interest in mineralogy and allied earth sciences and mineral resources of the various states.

A very attractive green and yellow Mineral Day Stamp has been issued by the Committee. It sells at 1c each and a large number have been sold. These may be obtained from Mr. D'Agostino.

Five additional members have been added to the National Advisory Committee. They are:

Dr. H. R. Aldrich, Geological Society of America.

Dr. H. A. Beuhler, State Geologist of Missouri.

Dr. Burnham S. Colburn, Southern Appalachian Mineral Society.

Dr. M. M. Leighton, State Geologist of Illinois.

Capt. Garland Peyton, Director, Division of Mines, Mining and Geology, Georgia.

## ANOTHER BIG DAY—MAY 19th, 1940

**Rocks and Minerals Association National Outing.**

Look on pages 168 and 169, in this issue, and then plan to attend one of the big outings that will be held on Sunday, May 19, 1940.

# ATLAS QUARRY NEAR PINE ISLAND, N. Y.

By PETER ZODAC
Editor, Rocks and Minerals

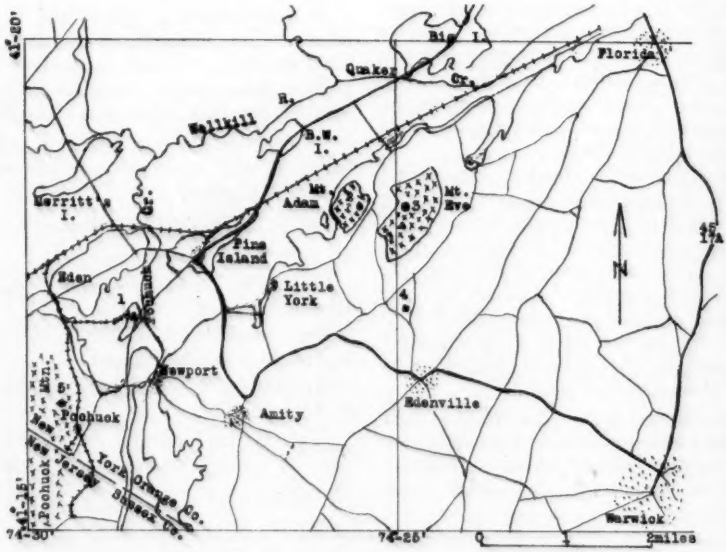
One of the few working limestone quarries in southeastern New York is located near Pine Island, Orange County. This is not only a large quarry but many interesting minerals occur in it. In deciding upon the outing for the New York Division of the Rocks and Minerals Association for May 19, 1940, the limestone quarry near Pine Island was selected.

## HISTORY

The quarry property was acquired by the Empire Steel and Iron Co., in 1906, being then known as the Empire Quarry. In 1924 the property was conveyed to the Warren Foundry and Pipe Co. The present owners, The Universal Atlas Cement Company, purchased the property in 1927 and installed new equipment. The stone is shipped to their plant at Northampton, Penna., the limestone from this quarry being added in small amounts to the cement rock quarried on their property at Northampton in the manufacture of Portland cement.

## LOCATION

Pine Island is an island about one mile long, N. E.—S. W., and one-half mile wide, in Warwick Township, in the southern part of Orange County—2½ miles northeast of the New Jersey border. It might not be perceptible at first glance that Pine Island is really an island, especially if it be visited when the onion crops of the region are in active growth. For the island is situated in the Drowned Lands of the Wallkill—a large marsh many miles in extent.




*Map showing locations of quarries and a mine near Pine Island, N. Y.*
*1—Atlas limestone quarry near Pine Island.*
*2—Granite quarry on Mt. Adam.*
*3—Granite quarry on Mt. Eve.*
*4—Arsenic mine near Edenville.*
*5—Granite quarry on Pochuck Mountain.*
Topography is from U. S. Geological Survey Goshen, N. Y.-N. J. Quadrangle Topo. Map.

In New York, at least around Pine Island, the partially drained marsh is utilized for the raising of Bermuda onions and for miles the plants may be seen growing in this rich soil. For those who love onions and their smell, here is an ideal spot for you!

The Pulaski Highway is the main thoroughfare through Pine Island on which is a small village bearing the same name, Pine Island.

The quarry is located one mile southwest of Pine Island village on another and smaller unnamed island, ½ mile long N-S, and less than ¼ mile wide. The quarry is 500 feet to the right (west) of the highway (a dirt road). Pochuck Creek flows north and bounds the island on the east.

The quarry is approximately 600 feet in diameter with walls 50 feet high.

## GEOLOGY

The rock of the quarry is a medium to coarse grained crystalline white limestone of Precambrian age[1] cut by igneous dikes.

The Drowned Lands of the Wallkill constitute a large marsh about 12 miles long and from 1 to 3 miles wide, extending into New Jersey. Originally it was much longer, Mather[2] having recorded it as 20 miles long and up to 5 miles in width. At that time the swamp was covered by several feet of water held in by a natural dam of glacial drift at the north end. A canal cut through this dam has redeemed the land. From the Drowned Lands there arise islands of limestone or drift which are named Pine, Great, Pellet's, Gardner's, Merritt's, Cranberry, Black Walnut, Fox and Seward's islands.[3]

Dr. Ries further stated[4]: "Of importance among the quaternary deposits of Orange county are the numerous old lake beds which especially abound in the Hudson river area. The lakes were formed by the damming up of the valleys and depressions between the slate ridges, and then disappeared through the subsequent filling of their basins or the cutting down of their outlets. Black soil underlies the surface to a depth of from five to fifty feet.*** The largest of these old lake bottoms is the Drowned Lands, which until fifty years ago was an undrained and useless swamp, but is now rich farming land. This area extends from Denton on the north to the New Jersey State line, a distance of twelve miles. Its width is from two to three miles and its area within the county is 17,000 acres. The lake had its origin in a drift dam northeast of Denton. The Wallkill river follows a winding course along the western side of this area, and submerges it entirely during the spring floods."

It is further interesting to note that the Wallkill, the largest river in the county, flows north, into Ulster County, to empty its waters at Rondout into the Hudson River which flows south.

## *MINERALOGY*

The Atlas quarry is noted for a number of interesting minerals and though every one may not be found on the first visit to the locality, repeated visits result in the finding of specimens not heretofore known. The following list comprises those known to the writer to occur here.

*Albite*: Grayish, translucent, cleavable masses in an impure grayish-green limestone.

*Amphibole var. Edenite*: Olive-gray crystalline masses, sometimes radiated, in white limestone.

*Amphibole var. Hornblende*: Dark green crystalline masses in igneous intrusions in the limestone.

*Amphibole var. Tremolite*: Grayish crystals in white limestone. The color of the tremolite is so light as to almost blend with the limestone and thus escape detection.

*Apatite*: Occurs as tiny, pale greenish crystals in coarse-crystalline white calcite.

*Aragonite*: Noted as grayish to brown botryoidal crusts on limestone.

*Calcite*: As the rock of the quarry is a crystalline limestone, calcite, its chief constituent, would naturally be the most common mineral present. It has been found

1 Newland, David H., **The Mineral Resources of the State of New York.** Bull. 223, 224, Albany, 1921, p. 257.
2 Mather, W. W., **Geology of New York.** Albany, 1843, p. 466.
3 Ries, Heinrich, **Report on the Geology of Orange County,** Albany, 1895, p. 474.
4 Ries: Work cited, pp. 465-466.

also in grayish-green crystalline masses with which cleavable masses of white calcite is asociated. Reddish and salmon were other colors noted for calcite. On July 10, 1939, large, coarse crystalline masses chalky-white in color, in which tiny graphite flakes were embedded, were found.

No calcite crystals from here are known to the writer.

*Chalcopyrite*: Sharp, lustrous, tiny crystals and grains were found in grayish-green calcite; also small masses in cleavable calcite.

*Chondrodite*: Occurs as reddish brown grains in white limestone.

*Fluorite*: Purple crusts on white limestone. Tiny purple cubes in white calcite were found July 10, 1939.

*Graphite*: Common as tiny grayish-black flakes and crystals disseminated in the limestone of all colors. Graphite is often associated with chondrodite. Some times graphite is so concentrated as to form small masses in the limestone.

*Limonite*: Present as yellowish-brown stains on limestone. Small pseudomorphs after pyrite crystals were also noted.

*Molybdenite*: Occurs as small to large lead-colored flakes and foliated masses of good quality in coarse crystalline white limestone, in a greenish limestone, in a mottled green and white coarse crystalline limestone, and in green serpentine. Apatite crystals and phlogopite are sometimes associated with molybdenite. Molybdenite is very common as huge masses of limestone are often well sprinkled with it.

*Muscovite*: Tiny colorless crystals in in cleavable calcite.

*Phlogopite*: Tiny crystals and flakes, bronzy yellow in color, in grayish-green limestone. As large flakes and crystals in cleavable calcite.

*Pyrite*: Noted as tiny cubes, small masses and films on calcite. Disseminated as tiny crystals and thin masses of good quality in coarse crystalline white calcite; also as small masses in dark green hornblende.

*Pyroxene*: Greenish and crystalline in white coarse crystalline calcite.

*Pyrrhotite*: Noted as tiny grains in greenish calcite; also as small grains up to masses 3 inches in diameter, often tarnished dull brown, in white limestone and associated with edenite. Sometimes the pyrrhotite has a lustrous bluish-black tarnish resembling that of bornite.

*Quartz var. Milky*: In small masses which appear greenish at times due to green pyroxene associated with it. The quartz in turn is associated with white, coarse crystalline calcite.

*Quartz var. Smoky*: Small masses in impure grayish-green limestone.

*Serpentine var. Asbestos*: Tiny veins of grayish-green, slightly altered fibers were noted in impure grayish-green limestone.

*Serpentine var. Common*: Common as greenish masses in limestone.

*Spinel*: Tiny blackish-brown rounded crystals in limestone were found July 10, 1939.

*Talc*: White flakes in serpentine; also green foliated masses in white cleavable calcite.

*Titanite*: Tiny brownish wedge-shaped crystals in grayish-green limestone; same in grayish limestone.

*Tourmaline*: Small brown crystals in white cleavable calcite.

*Wernerite*: Dark gray slender crystals, also slightly radiated dark gray groups and both in white limestone; sometimes graphite is imbedded in the radiated crystals giving them a black color.

*Zircon*: Small gemmy brown crystals in limestone have been found by Clifford Frondel of Harvard University.

ACKNOWLEDGEMENTS

The grateful thanks of the writer are extended to Mr. M. W. Winsch, General Superintendent of the Universal Atlas Cement Co., for permission to hold the outing at their Atlas Quarry near Pine Island and for information relative to the history of the quarry; to Mr. Fred Babcock, Superintendent of the Atlas Quarry for many courtesies extended the writer; and to Mr. Clifford Frondel of Harvard University for notes on minerals found by him and for identifying some of our rarer finds.

# NEW ENGLAND NOTES

**Conducted by Rudolf C. B. Bartsch**

36 Harrison St., Brookline, Mass.

This new section of our magazine will be devoted entirely to notes and items directly connected with New England. The opening of new or old localities, unusual finds and other matters of interest to the collectors in this area and to those that may at sometime or another pay us a visit, will be presented as soon as available. Contributions from collectors will be gladly accepted.

*Bolton, Mass.* This famous old locality has been in active operation for the past year after a shut-down of a generation or two. Originally the quarry was worked for lime and the old kiln can still be seen. The present operation consists in grinding the limestone to dust size and selling it for agricultural lime. A large amount of material of interest to the mineral collector is available. Excellent scapolite of a fine pinkish lavender color is plentiful. Forsterite (boltonite) in both dark greenish gray and yellow brown color can be secured in fine specimens. Other minerals, such as vermiculite, diopside, calcite, actinolite, apatite (blue), and serpentine are to be had in fine specimens. Many others are to be found with some luck and hard work. No spinel has as yet been reported in the new operation. This locality is easily reached as it is just off the main highway between Bolton and Stow, Mass. At the present time there is no restriction on collecting at the locality.

*Diamond Hill, Cumberland, R. I.* This grand old locality for quartz in many forms and excellent material is now closed to the collector. NO TRESPASSING signs were placed on the property last fall. The writer does not know whether or not passes to enter the property can be secured. As soon as this information is available it will be announced in this column.

*Grafton, N. H.* This is New England's most famous locality for fluorescent and radio-active minerals, as well as other interesting minerals. Do not expect to enter this property without first obtaining written permission. This may be secured by writing The Whitehall Co., Gilsum, N. H., and enclosing stamped return envelope. Autunite, gummite, uraninite and many other uranium minerals are to be had in excellent specimens. Fine apatite crystals and fine pink montmorillonite are plentiful.

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The Boston Mineral Club at its February meeting heard Prof. Robert L. Nichols, of the Department of Geology, Tufts College, describe the wonders and beauty of our national parks. Many beautiful slides were shown as well as many fine specimens from the various localities.

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Danalite, one of the rarest of New England minerals and of which there are perhaps not over a dozen specimens and a few small loose crystals, is recorded in Dana's *System of Mineralogy* as occurring in Rockport, Mass., and Bartlett, N. H. The Bartlett crystals are small and occur with magnetite and quartz at the iron mine. The Rockport material is found in pegmatite veins cutting granite. Some fifteen or more years ago when the granite quarries at Rockport were in operation, a few specimens of this rare mineral were found. The quarries have been inactive for several years and now are all flooded and there is great doubt if they will ever be operated again. Last fall Mr. Gunnar Bjareby and the writer were extremely fortunate in finding two superb specimens of this rare mineral after a long search and considerable hard work. Some excellent specimens of fayalite, and lepidomelane (annite) were also secured. The writer also found a superb piece of quartz of a vivid Berlin blue color and opalescent.

## AS TO ASBESTOS FIBER LENGTH

Dr. Oliver Bowles, Assistant Chief Engineer, Nonmetal Economics Division, U. S. Bureau of Mines, Washington, D. C., has written to us regarding the importance or unimportance of asbestos fiber length, after reading our article in a recent issue of ROCKS AND MINERALS, on the longest fiber length of amphibole asbestos of which we had heard up to that time. Dr. Bowles' letter is so interesting we quote it below in full.

"With reference to your item on page 80 of the March issue of ROCKS AND MINERALS concerning long asbestos fiber found in Rhode Island, fiber length of amphibole asbestos is of little significance because generally the fibers are so weak and brittle that, unless handled with great care, the long fibers are broken into shorter lengths. Certainly from a commercial standpoint fiber length of amphibole is of little importance because during the milling or fiberizing process the fibers are of necessity broken into relatively short filaments. As a matter of fact amphibole fibers much longer that 14¼ inches have been found. Several years ago we had a mass of fiber sent to the Bureau of Mines from some southern locality of which I no longer have the record and it was necessary to remove with a handsaw several inches from the end of this mass in order to accommodate it to a glass case 31 inches long inside measure. The fibers could be traced continuously for the entire length of this sample, approximately 36 inches, but because of their weakness, it would be difficult to separate a small group of fibers of this length.

"Crocidolite, amosite, and chrysotile fibers on the other hand are as strong and flexible as silk, and the original fiber-length is commonly retained in the prepared fiber even though it may be subjected to rough treatment. For these varieties, length of fiber is very important from a commercial standpoint. Therefore in establishing records of length, it would seem desirable to restrict comparisons to the spinning fibers."

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## World's Largest Topaz Crystal in New York Museum

The world's largest topaz crystal, 596 lbs. in weight, has recently been placed on exhibition in the Mineral Hall of the American Museum of Natural History, New York City. The huge crystal is colorless, has good sharp faces but is much fractured. It is approximately 24" x 30" x 19" high, and was found in Minas Geraes, Brazil.

The crystal has been mounted in a glass case 3' x 3' x 30" high whose base is 3' x 3' x 3' in size. A strong light in the base shines through the crystal giving it a yellowish color.

The topaz crystal represents the first addition to the William Boyce Thompson collection.

## ** Crystallography **

### ("BOYLED" DOWN)

Neither prism nor base
Can enclose any space —
Nor can pinacoids
Enclose any voids;
But a base *and a* prism
*Will* have space in 'em,
And a pinacoid might
Substitute for a prism.
The pole-vaulting dome
Skips lightly the *c*,
And is easily at home
With A or with B;
But the pyramid, more stable,
Does the best he is able—
And hugs tightly on to A, B, and C.

J. C. BOYLE

(*Pay Dirt*, official journal of The Brooklyn Pick and Hammer Club, Brooklyn, N. Y., Children's Museum, March, 1940).

# Collectors' Tales...

By PETER ZODAC

## A CROW THERE WAS AND HE A FOOLISH BIRD

Not long ago Joe deLuca had occasion to put in a small blast in an old emery mine near Peekskill, N. Y., which he had recently leased. The shot was to be fired by a time fuse. After the fuse was lit and he and his foreman had retired to a safe distance behind some big trees, not far away, and were looking towards the pit, the foreman spoke up.

"Do you see what I see?"

"Yes, I do," replied Joe "and I am wondering what will happen."

The object of their talk was a huge crow which had appeared from nowhere and who persisted in flying leisurely but a few feet above the very pit in which the blast was to go off.

Suddenly there was a puff of smoke; then the sharp roar of a dynamite blast. Rocks, large and small, flew upward in all directions, and then, a few seconds later, down fell many black feathers to settle slowly over the erupted area. The crow, however, still flying leisurely, slowly disappeared from view, apparently not the least bit ruffled by the blast nor even by the loss of its many feathers.

Joe insists that not more than three feathers remainded on the bird and that they were badly bent and wrinkled so that the crow could not fly fast even if it wanted to. The foreman, on the other hand, swears that there wasn't even one feather left on the bird and that he was simply coasting down to earth.

If any one doubts this tale, Joe will be glad to show him some of the feathers which he gathered and is preserving for this very purpose. If you are ever around Peekskill, call at the deLuca's emery mine, on Croton Avenue, and ask to see the broad shouldered, good-looking mine operator. Joe will show you the feathers and also his mine including the very pit in which the blast was fired.

## ASSOCIATION MEMBERS GIVEN PUBLICITY

Two Rocks and Minerals Association members who have recently received very favorable press notices due to their large mineral collections are Oris U. Armstrong of Portland, Maine, and Frank W. Hess of Springfield, Mass.

Mr. Armstrong specializes in fluorescent minerals, his collection of these alone weighing over one ton, and has created intense interest in mineralogy in his city through the showing of his collection to visitors and by lectures.

Although possessing a huge amount of specimens, Mr. Armstrong began collecting during August, 1939, less than a year ago. Here is concrete evidence how one can build up a mineral collection if he is sincerely interested in the subject. We know of some individuals who have been collecting for years and yet their entire collection can fit into a small brief case with room to spare.

Mr. Armstrong's press notice appeared in the Sunday, Jan. 28, 1940 issue of the *Portland Sunday Telegram and Sunday Press Herald*. It consisted of one full and two short columns illustrated by a good picture of him holding a 22-lb. fluorescent specimen in his hand and standing near some tables on which a number of specimens were displayed.

Mr. Hess began collecting about 1935 and his collection now embraces about 1,000 fine specimens. It contains a large number of New England specimens many of which he personally collected. On one occasion he actually worked a mine for specimens. With a friend and the owner of the old lead mine in Whately, Mass., the three obtained some dynamite, drilled holes in the rock at the mine, and blasted. The result was a lot of good specimens for their collections.

Mr. Hess' press notice appeared in the Sunday Feb. 25, 1940, issue of *The Springfield Sunday Union and Republican* which occupied three long columns and illustrated by a fine picture of him kneeling before one of his cabinets.

# 8th NATIONAL OUTING
## OF THE
# ROCKS AND MINERALS ASSOCIATION
### SUNDAY, MAY 19, 1940

Due to the fact that your Secretary was on the sick list for about two months the very time when plans for the Annual Outing should have been made, it was not possible to communicate with those clubs and directors who formerly took charge of the Outing in their sections of the country. This explains the small number of groups participating this year. Even at this late period there is still time for clubs to cooperate with the Association—by holding outings on May 19th in their respective communities.

If an outing is to be held in your area, it is suggested that you register with your director at an early date. Just drop him a post card stating that you will attend the outing. If those having cars could accommodate one or more extra passengers, it would be considered a great favor if they would so inform their directors. If no group outing is to be held in your vicinity, then hold one of your own, inviting your friends to join you.

Collectors should wear stout shoes and rough clothes and each be provided with a mineral hammer, collecting bag, small note book, pencil, magnifying glass, pen knife, and newspapers. Bring LUNCH.

***NOTE — Please be careful around mines and quarries. Neither the Association nor the directors nor even the owners of property on which outings may be held will be responsible for any accidents incurred by those participating.***

The states in which outings will be held are are follows:

CALIFORNIA

*NOTE*: This outing will be held Sunday, May 12th.

*Director*: E. V. Van Amringe, Pasadena Junior College, Pasadena.

*Locality and Meeting Place*: Contact the Director for particulars.

CONNECTICUT
(HARTFORD BRANCH)

*NOTE*s This outing will be held Sunday, May 12th.

*Director*: Mrs. Ralph F. Hills, 35 Manchester St., Hartford.

*Locality*: Hale Quarry near Portland, Conn.

*Meeting Place*: In front of Clapp & Treat's Store, 4 American Row, Hartford, at 9:00 a.m.

CONNECTICUT
(NEW HAVEN BRANCH)

*Director*: Mrs. Lillian M. Otersen, 16 Grove Place, West Haven.

*Localities*: Trap rock quarries of New Britain and Farmington, Conn.

*Meeting Place*: In front of Peabody Museum, on Whitney Ave., corner Sachem St., New Haven, Conn., at 9:00 a.m.

MASSACHUSETTS

*Director*: John E. Kitson, 30 Briggs St., Easthampton.

*Localities*: Dinosaur Ledge, Smith's Ferry, Mass., and a local trap rock quarry.

*Meeting Place*: At the Dinosaur Ledge at 1:00 p.m. D.S.T.

*Note*: Smith's Ferry is on Route 5 just north of Holyoke. The Ledge will be clearly marked with signs. Prof. Robert Balk of Mt. Holyoke College will address the group.

NEW JERSEY

*Director*: Louis Reamer, 484 Lincoln Ave., Orange, N. J.

*Locality*: Atlas limestone quarry near Pine Island, N. Y.

*Meeting Place*: At the quarry at 11:00 a.m.

*Note*: This is a joint outing with the New York group.

NEW YORK

*Director*: P. Zodac, Box 29, Peekskill.

*Locality*: Atlas limestone quarry near Pine Island.

*Meeting Place*: At the quarry at 11:00 a.m. D.S.T.

*Note*: See article in this issue on the quarry.

RHODE ISLAND

*Director*: Dr. Alonzo Quinn, Dept. of Geology Brown University, Providence.

*Locality*: Strickland quarry, Portland, Conn.

*Meeting Place*: Rhode Island Hall (on George Street), Providence, at 9:30 a.m. D.S.T.

# CLUB and SOCIETY NOTES

## New Haven Mineral Club

The May meeting of the Club will be held on Monday the 20th, in Room 218, 19 Congress St., New Haven, Conn. The guest speaker will be Mr. James G. Manchester who will give an illustrated talk on the collecting of chalcedony pseudomorphs in Florida.

The second field trip of the year will be held on Sunday, May 19, to the trap rock quarries of New Britain and Farmington, Conn. This trip is held in conjunction with the Annual Outing of the Rocks and Minerals Association.

## Newark Mineralogical Society

The 192nd regular meeting of the Society was held in Junior Hall, 468 Orange St., cor. N. 6th St., Newark, N. J., Sunday, April 7, 1940, at 3:00 p.m. After the routine business had been transacted, the guest speaker, Peter Zodac, Editor of *Rocks and Minerals*, spoke on some mineral localities of Putman and Westchester Counties, New York; the talk was illustrated with many specimens from some of the localities described.

Several of the members present had a number of very fine New York specimens on display; these specimens were described briefly by their exhibitors.

The Society voted to cooperate with the Rocks and Minerals Association at the Annual Outing to be held on Sunday, May 19, 1940.

Twenty-six members and guests were present at the meeting. R. P. Milburn was the presiding officer assisted by W. E. Simpson, Secretary, and W. H. Broadwell, Treasurer.

## Ohio Gemolgists Guests of Mineralogical Society

Member of the Northern Ohio Guild of the American Gem Society were invited as guests of the Cleveland Mineralogical Society for the March lecture meeting held in the Mineralogical laboratories of Pierce Hall of Western Reserve University.

The Speaker of the evening was the Reverend Frank Joliet, nationally known Seismologist of John Carroll University who spoke on the subject of Earthquakes and their Causes.

It is a well known fact that earthquakes are important factors in causing changes in geological formations of the earth's crust.

Fr. Joliet's interesting lecture was illustrated with slides showing the seismograph, earthquake charts and the pictorial results of past quakes.

## Mineralogical Society of Hartford

At the April meeting of the Society, held in Hartford, Conn., the following officers were elected:

President—Harold P. Crosby
Vice-President—Ralph F. Hills
Treasurer—Fred W. Webster
Secretary—Mrs. L. T. Goodrich

A field trip to the Hale Quarry near Portland, Conn., will be held on Sunday, May 12th. See page 168, this issue, for further information on this trip.

## Calcite Crystals Found Below Sea Level

The North Tunnel of Shaft No. 7 which is in the southern part of Dutchess County, about one mile east of Route 9, in New York State, is penetrating Wappinger limestone of Cambro-Ordovician Age. Wappinger limestone is a dark gray to almost black, finely crystalline rock which in the tunnel is so penetrated by numerous joints, filled with calcite, that large blocks free from them are unknown. The tunnel is 330 feet below sea level.

The surprising part about the limestone found in the tuunel is that at its great depth below sea level it contains small vugs or cavities lined with tiny white to colorless calcite crystals. Furthermore the crystals are both fluorescent and phosphorescent.

Shaft No. 7, which is 777 feet in depth, is one of the links in the new aqueduct now being constructed by the City of New York.

# BIBLIOGRAPHICAL NOTES

*Mineral Collectors Catalog (No. 401):* Lists mineral specimens alphabetically with a brief description of each, with prices. Fluorescent lamps, fluorescent minerals, supplies for the collector and books and other items featured; 32 pp. with a number of illustrations.

This new catalog from the world's largest mineral dealers is an indication of the continued heavy demand by collectors for choice mineral specimens. Stocks of minerals are depleted so rapidly that it is necessary to issue new catalogs frequently to keep puce with mineral collecting.

Issued by Ward's Natural Science Establishment, Inc., P. O. Box 24, Beechwood, Sta., Rochester, N. Y.

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*Meteorites and Rocks*: A catalog (16 pp., 6 illus.) listing many meteorites and rock specimens carried in the huge stock of the world's largest mineral dealers, Ward's Natural Science Establishment, Inc., P. O. Box 24, Beechwood Sta., Rochester, N. Y.

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*Outline Geologic Map of California Showing Locations of Quicksilver Properties*: Prepared under the direction of Olaf P. Jenkins, Chief Geologist, 42 x 36 inches, 1939.

Issued by the State of California, Division of Mines, Ferry Bldg., San Francisco, Calif.

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*Northampton County, Pennsylvania:* Geology and Geography by Benjamin LeRoy Miller with a chapter on Pre-Cambrian Geology by Donald McCoy Fraser and on the Jacksonburg Formation by Ralph LeRoy Miller. A very fine report on the geology and mineralogy of the county which contains many mines and quarries of which the most noted, perhaps, is Williams Quarry of Easton. The report is cloth bound and contains 496 pp., 29 pls. 36 figs., and one geologic map in color, 31 by 32 inches. Copies are $2.25 each and are obtainable from the Division of Documents, Dept. of Property & Supplies, 10th & Market Sts., Harrisburg, Penna.

Prof. Miller, the senior author of this very interesting report, is a member of the Rocks and Minerals Association and we heartily recommend the bulletin to our members. Another report that should be of great interest to our members, which was also prepared by Prof. Miller, though issued a few years ago, is *Limestones of Pennsylvania.* It is cloth bound, contains 729 pp., 41 pls., 37 figs., and priced at $2.00. It, too, is obtainable from the Division of Documents.

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*Annual Progress Report of the Geological Survey for the year 1938:* 34 pp., 8 pls. Issued by the Geological Survey of Western Australia, Perth, Western Australia, 1939.

*Bulletin du Service des Mines No. 3* (in French): Issued by the Gouvernement General de L'Afrique Occidentale Francaise, Daker, Senegal, Africa, 94 pp., 24 figs., 6 pls.

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*Annual Report of the Quebec Bureau of Mines for the Calendar Year 1936. Part D.*

Mount Alexander Map-Area, Gaspe Peninsula, by I. W. Jones, pp. 5-26.

Saine-Anne River Map-Area, Portneuf County, by Abbe J. W. Laverdiere, pp. 27-49.

The report, recently issued, contains 49 pp., 14 pls., 3 figs, 2 maps, and is obtainable from the Quebec Bureau of Mines, Quebec, Canada.

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*California Mineral Production and Directory of Mineral Producers for 1938:* (Bull. 117). By Henry H. Symons. A valuable and interesting report on the commercial minerals produced by the State in 1938; 216 pp., 7 illus. Issued by the Division of Mines, Ferry Building, San Francisco, Calif.

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*The Geology of the Yilgarn Goldfield, South of the Great Eastern Railway:* By H. A. Ellis, B. Sc., A. O. S. M., with an appendix by Dorothy Carroll, Ph.D., D. I. C., on "Sand-Plain Soils from the Yilgarn Goldfield." 192 pp., 15 figs, 7 folded maps. (1939). Issued by the Western Australia Geological Survey, Perth, Western Australia, as Bull. No. 97).

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*Rock Drilling:* By C. E. Nighman and C. E. Kiessling. Issued by the Works Project Administration, National Research Project, in cooperation with the Department of the Interior, Bureau of Mines, (Report No. E-11), Philadelphia, Penna., Feb. 1940, 158 pp., 27 figs.

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*Barite Deposits of Virginia:* By Raymond S. Edmundson. This interesting report contains description of the barite mines and prospects, brief mention of the associated rocks and minerals, and a section on mining methods and suggestions for prospecting. The report (Bull. 53) contains 85 pp., 15 pls., 15 figs., and is issued by the Virginia Geological Survey, University, Va.

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*Geologic Antiquity of the Lindenmeier Site in Colorado*: By Kirk Bryan and Louis L. Ray, 76 pp., 6 pls., 13 figs. Issued by the Smithsonian Institution, Washington, D. C., Feb. 1940, as Publication 3554.